

Mapping Physical Characteristics of the Columbia River Mouth Using Transmitted Diving Waterbirds

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LONG-TERM GOALS

The long-term goal of the project “Mapping Physical Characteristics of the Columbia River Mouth Using Transmitted Diving Waterbirds” is to investigate the use of diving waterbirds as sensor platforms to collect physical oceanographic data. Waterbirds may offer novel sampling opportunities in coastal waters, including areas difficult to access or under hydrologic conditions where traditional sampling equipment is difficult to safely or successfully operate. Our efforts are specifically designed to support the RIVIT II Inlet and River Mouth Dynamics Departmental Research Initiative at the Mouth of the Columbia River (MCR).

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OBJECTIVES

The objectives of this project are to:

- Investigate the use of cormorants (*Phalacrocorax* spp.) as platforms to measure conductivity, temperature, and depth across the MCR
- Investigate the use of cormorants to collect river/sea bed imagery across the MCR
- Collaborate with other RIVET II scientists to incorporate data collected into the development and/or validation of spatially-explicit models of salinity, bathymetry, bed form, or other physical features for the MCR.

APPROACH

The spatial distribution of individual foraging cormorants can be precisely mapped using Global Positioning System (GPS) tags. GPS-tagged cormorants can then be fitted with an additional sensor tag(s), or birds can be fitted with single tags that integrate both GPS functionality and sensor capability, to collect a variety of spatially explicit physical and oceanographic data. Bathymetry can be sampled using tags that collect a pressure-based measurement of depth. Salinity and temperature patterns can be measured by affixing tags incorporating a conductivity meter and temperature sensor. Visual imaging of the river/sea bed might be accomplished by affixing either a still-image or video camera to GPS-tagged cormorants.

Nesting cormorants are attractive candidates for this type of sampling because archival tags can be recovered by re-capturing the bird when it returns to the nest following foraging bouts. Cormorants nesting at East Sand Island (river kilometer 8 in the MCR) sample a large portion of the estuary and near-shore areas surrounding the MCR. Through unrelated ecological research funded by other sources, we have access to cormorants nesting at this site and are able to leverage that access and infrastructure to capture cormorants, affix tags, release tagged individuals, and recapture those individuals following the data collection period. Tag deployment and recovery can occur with a high rate of success (minimal tag loss) while nesting cormorants are incubating eggs and/or rearing younger chicks (typically from early May until late June). Tags can be affixed to birds using a backpack harness configuration, so that the tag(s) rides on the back of the bird, out of the water when the bird rafts on the surface (Courtot et al. 2012).

Given the short time interval between the receipt of the award and the 2013 cormorant breeding season, we selected commercially available tags that had previously demonstrated successful deployments on diving waterbirds for the majority of our deployments. Our primary choice of supplier for GPS tags was Earth and Ocean Technologies (Kiel, Germany). These tags integrated GPS capability with sensors to measure pressure (depth) and temperature into a single, compact package. The temporal response of temperature and pressure measurements in these tags is quite good (stabilization time < 2 sec). Four conductivity/temperature/depth (CTD) tags from Star-Oddi (Garðabær, Iceland) were purchased to relate conductivity to temperature on a sample basis, although stabilization time on the temperature measurement was relatively poor (up to 20 sec). An additional two GPS-only tags were purchased from Skorpa Telemetry (Aberfeldy, Scotland) to evaluate a novel GPS technology (“Snap” technology) that offered a potential low-power, long-life GPS alternative.

WORK COMPLETED

Due to delays in the manufacturing process, the majority of tags were delivered to us in the middle of July, late in the cormorant breeding season. Nonetheless, we conducted six tag deployments before the end of the cormorant breeding period, when further deployments were rendered unfeasible.

Deployment of a larger sample size of tags and collection of a more robust data set are planned for the 2014 cormorant breeding season.

The initial six deployments consisted of a three way split. We fitted two Brandt's cormorants (*P. penicillatus*) with each of the following three tag configurations (a total of six birds received tags):

- Earth and Ocean Technologies GPS/depth/temperature tag
- Earth and Ocean Technologies GPS/depth/temperature tag and a Star-Oddi CTD tag
- Skorpa GPS ("Snap") tag

Tags were recovered from five of the six birds on which tags were deployed. One bird that received only an Earth and Ocean Technologies tag abandoned its nesting effort and was not recaptured; the cause of this nest abandonment was undetermined.

An off-the-shelf underwater camera suitable for use on Brandt's or double-crested (*P. auritus*) cormorants was not identified prior to the 2013 cormorant breeding season. Further communication with vendors or possible development or modification of existing cameras here at Oregon State University will be investigated prior to the 2014 season.

Preliminary data summaries have been completed. Calibration of raw data and data analyses are ongoing.

RESULTS

Data collection periods ranged from 2 to 5 days per bird. Birds utilized an extensive range of sites at the MCR, from just below the Astoria-Megler Bridge in the estuary out to well beyond the river jetties in the near-shore region (Figure 1).

Location fixes were recorded for all five birds from which GPS tags were recovered. GPS tags from Skorpa showed some promise for collection of location data using the low-power Snap technology; however, data from the Skorpa tags suffered from intermittent poor satellite reception, firmware problems, and one tag was subject to water leakage and battery failure prior to completing the anticipated data collection period. Tags from Earth and Ocean Technologies and Star-Oddi collected data with greater reliability.

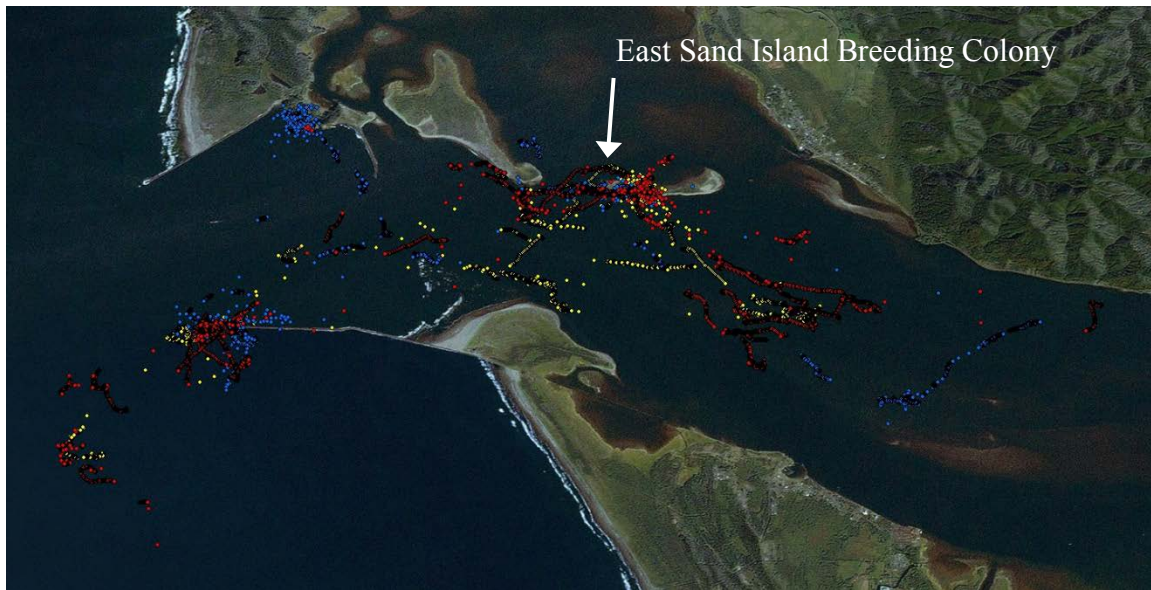


Figure 1. Foraging locations of three Brandt's cormorants at the mouth of the Columbia River. Foraging locations for each bird are shown in a distinct color (red, yellow, or blue)

When diving to depths greater than 2 m, cormorants frequently displayed a U-shaped dive profile (Figure 2). This type of dive profile is generally indicative of dives to the river/sea bed and foraging on benthic prey (Schreer et al. 2001).

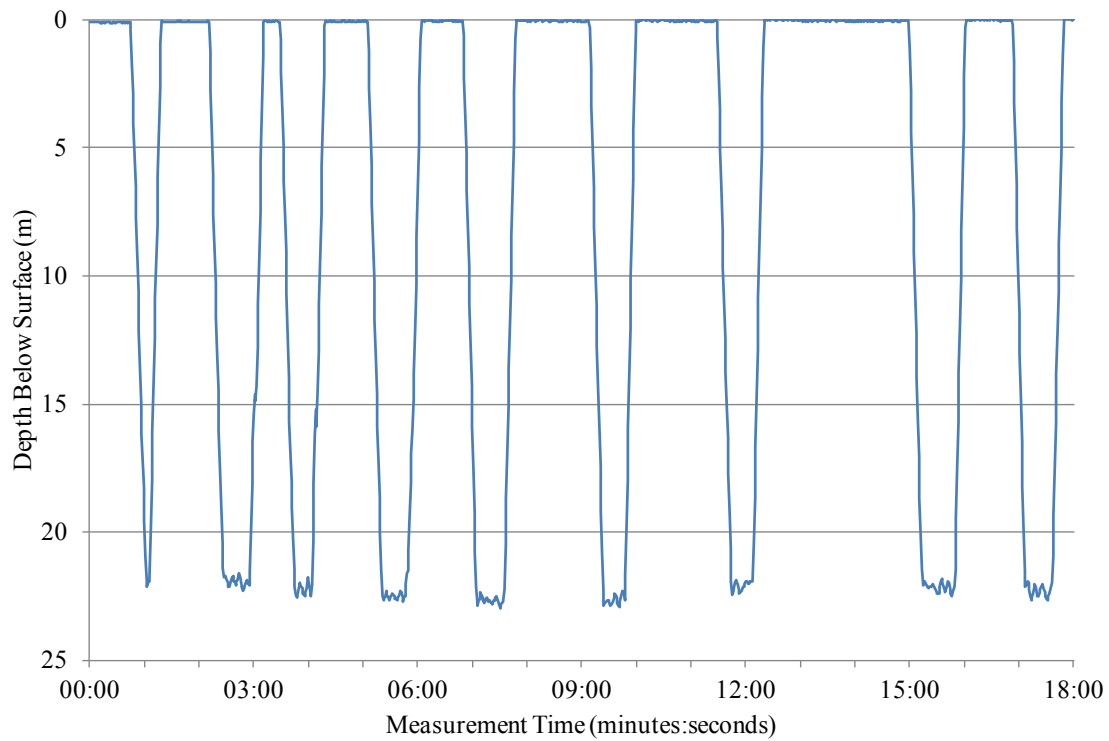


Figure 2. Example dive profiles (depth vs. time) of an individual Brandt's cormorant at the mouth of the Columbia River. These preliminary estimates of depth do not incorporate corrections for variation in water density, tide stage, or other factors.

Individual cormorants conducted from 37 to 127 apparent foraging dives (> 2 m in depth) per day. Raw dive depths (uncorrected for variable water density, tide stage, and other factors) suggested some dives were in excess of 20 m beneath the surface (Figure 3). Duration of apparent foraging dives ranged from 4 – 84 seconds (mean = 26 sec).

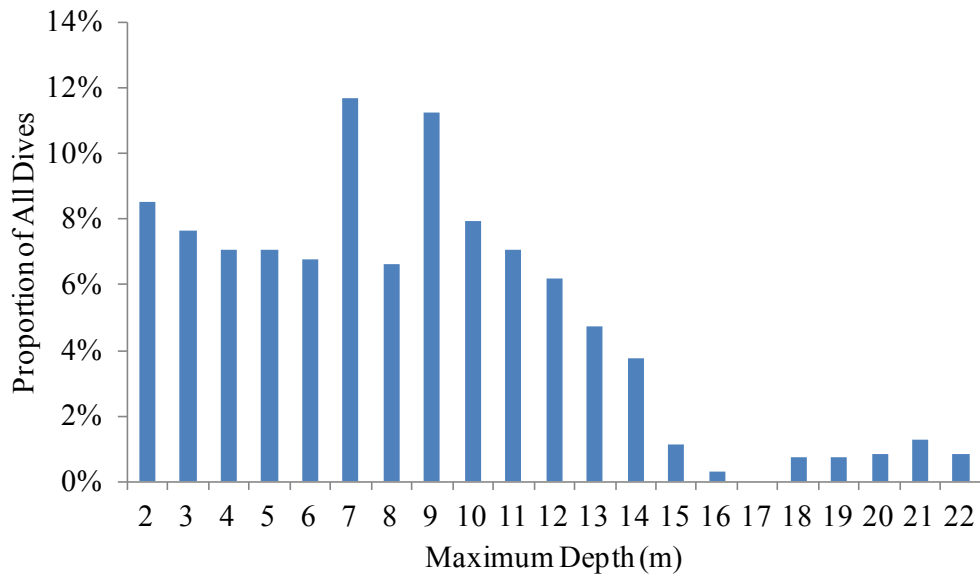


Figure 3. Maximum depth distribution of apparent foraging dives (> 2 m deep) by Brandt's cormorants at the mouth of the Columbia River. Preliminary depth estimates are not corrected for variation in water density, tide stage, or other factors.

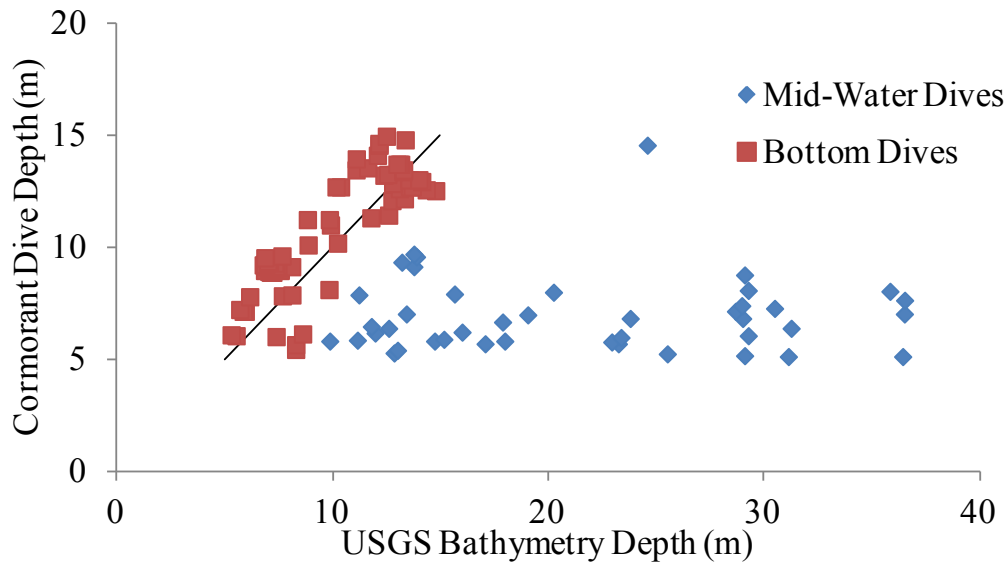


Figure 4. Preliminary analysis comparing sonar-derived bathymetry data (courtesy G. Gelfenbaum, U.S. Geological Survey) and coincident maximum dive depths of Brandt's cormorants at the mouth of the Columbia River. Preliminary estimates of cormorant dive depths are not corrected for variation in water density, tide stage, and other factors. Only cormorant dives deeper than 5 m are shown. A line depicting bathymetry depth at the location of dives is shown for reference.

Preliminary estimates of the maximum depths of most geolocated U-shaped dives by cormorants are consistent with bathymetry data collected using a shipboard SWATHplus-M interferometric sidescan sonar system during May and June 2013 (data courtesy G. Gelfenbaum, U.S. Geological Survey; Figure 4). These preliminary results suggest that cormorants can be used to sample bathymetry in areas where they forage. Incorporation of corrections for variation in water density, tide stage, and other factors in the calculation of depth from cormorant pressure measurements will undoubtedly improve this correlation.

IMPACT/APPLICATIONS

The preliminary data collected during the 2013 breeding season demonstrates the potential use of cormorants to measure various physical oceanographic parameters. We were successful in capturing nesting adult cormorants and outfitting them with GPS units to track their position, and attaching multiple sensors of different types to collect oceanographic data. Cormorants sampled a substantial portion of the Columbia River mouth, including sites with different depth, temperature, and salinity. Initial data analysis indicates that maximum dive depths are consistent with sonar-derived bathymetry data, in areas where such data are available. Further analyses are ongoing. In 2014, it will be possible to collect substantially more data at the MCR and more fully demonstrate the utility of diving waterbirds as oceanographic sensor platforms.

RELATED PROJECTS

We are collaborating closely with Dr. James Lerczak (Oregon State University), another participant in the ONR RIVIT II MCR DRI, on all aspects of this work. He will assist in the initial analysis of 2013 data and subsequent analyses of 2014 data, as well as consult on 2014 tag deployment strategies.

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